Istituto Nazionale di Geofisica e Vulcanologia

3D FINITE ELEMENT MODELING OF THE 2009 L'AQUILA EARTHQUAKE DEFORMATION FIELD

U23A-0016

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INTRODUCTION

The L'Aquila earthquake (Mw 6.3) occurred on April 6th at 01:32 UTC in the Central Appennines at a depth of about 9 km and was felt all over Central Italy. The main shock was preceded by a long seismic sequence started several months before and was followed by thousands of aftershocks, some of them with Mw>4.

In the present work we computed the coseismic deformation field induced by the earthquake by means of a 3D Finite Element (FE) analysis. To this effort we implemented different seismic source models obtained from fault inversion of GPS measurements, joint inversion of strong motion and GPS data and joint inversion of DInSAR displacements and GPS data.

SOURCE MODELS

FAULT PLANE WITH HOMOGENEOUS SLIP DISTRIBUTION
from inversion of GPS data (Anzidei et al. 2009)

strike angle=141.6°
dip angle=54.5°
rake angle=-93.8°

1

FAULT PLANE WITH HETEROGENEOUS SLIP DISTRIBUTION
from joint inversion of strong motion and GPS data (Cirella et al. 2009)

strike angle=133.°
dip angle=54.°
rake angle= variable

2

FAULT PLANE WITH HETEROGENEOUS SLIP DISTRIBUTION
from inversion of DInSAR coseismic displacements (Atzori et al. 2009)

strike angle=133.5°
dip angle=47.°
rake angle=-103.5

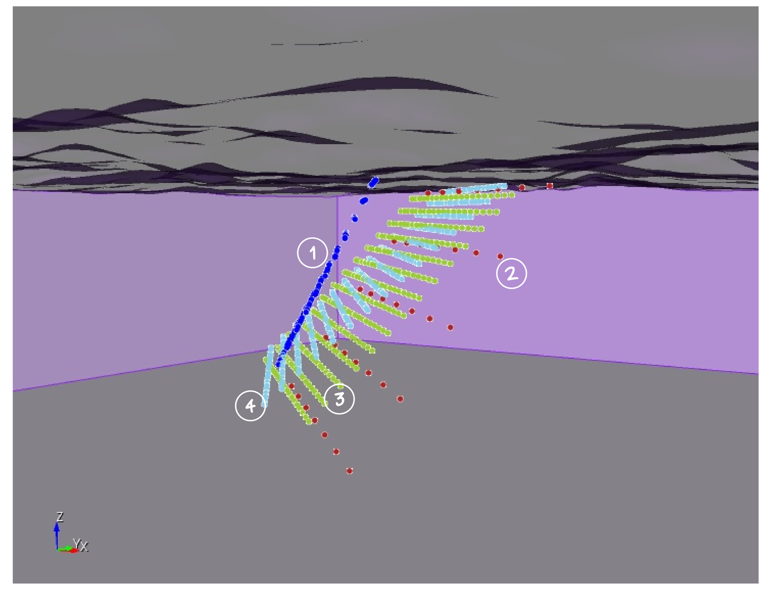
3

FAULT PLANE WITH HETEROGENEOUS SLIP DISTRIBUTION
from inversion of DInSAR coseismic displacements (Trasatti et al. 2009)

strike angle=142.°
dip angle=42.°
rake angle= variable

4

WORK IN PROGRESS



M. Anzidei, E. Boschi, V. Cannelli, R. Devoti, A. Esposito, A. Galvani, D. Melini, G. Pietrantonio, F. Riguzzi, V. Sepe, and E. Serpelloni (2009), Coseismic deformation of the destructive April 6,2009 L'Aquila earthquake (central Italy) from GPS data, Geophys.Res. Lett., 36, L17307, doi:10.1029/2009GL039145
A. Cirella A. Piatanesi, M. Cocco, E. Tinti, L. Scognamiglio, A. Michelini, A. Lomax, and E. Boschi (2009), Rupture history of the 2009 L'Aquila (Italy) earthquake from non-linear joint inversion of strong motion and GPS data, Geophys. Res. Lett., 36, L19304, doi:10.1029/2009GL039795
S. Atzori, I. Hunstad, M. Chini, S. Salvi, C. Tolomei, C. Bignami, S. Stramondo, E. Trasatti, A. Antonioli, and E. Boschi (2009), Finite fault inversion of DInSAR coseismic displacement of the 2009 L'Aquila earthquake (central Italy), Geophys. Res. Lett., 36, L15305, doi:10.1029/2009GL039293
E. Trasatti, C. Kyriakopoulos, S. Atzori, M. Chini, S. Salvi, FEM inversion of DInSAR data of the 2009 L'Aquila Earthquake (Italy) POSTER U23A-0015

COMPUTATIONAL TOOLS

The model was built and meshed by means of CUBIT, from Sandia National Laboratories (http://cubit.sandia.gov/index.html), a powerful and full-featured software toolkit for robust generation of two- and three-dimensional FE grids and geometry preparation.

The FE simulation was carried out by FEMSA, a recently developed FE simulation tool (Volpe et al. 2007). It is based on CalculiX, (http://www.calculix.de/), a free package designed to solve field problems.

FEMSA
Finite Element Modeling for Seismic Applications

The main features of simulating with FEMSA are:
- the seismic source is implemented as a suitable distribution of double couples of forces
- arbitrary fault geometry and slip distribution are allowed
- inhomogeneous boundary conditions are applied by prescribing analytically computed displacements to the edge nodes (Okada model).

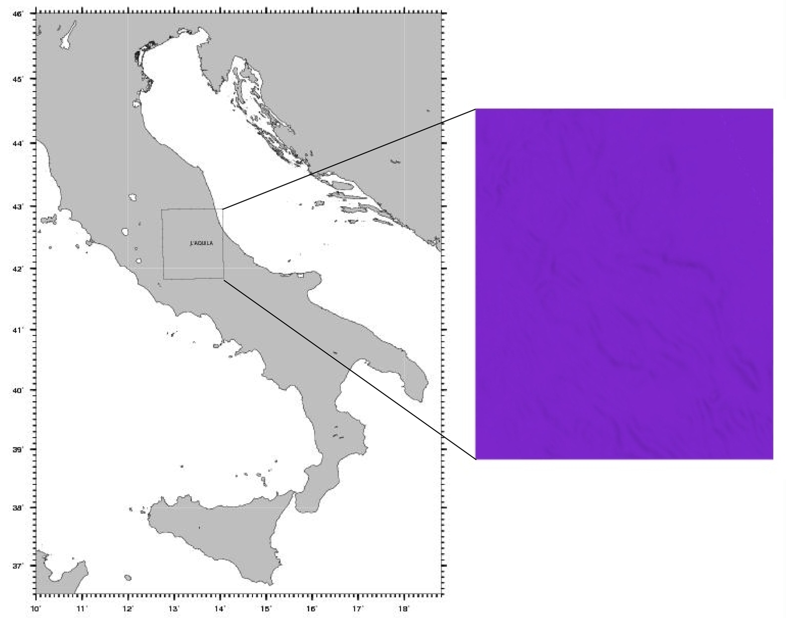
M. Volpe, D. Melini, A. Piersanti, FEMSA: a finite element simulation tool for quasi-static seismic deformation modeling, Annals of Geophysics (2007), 50: 367

THE MODEL

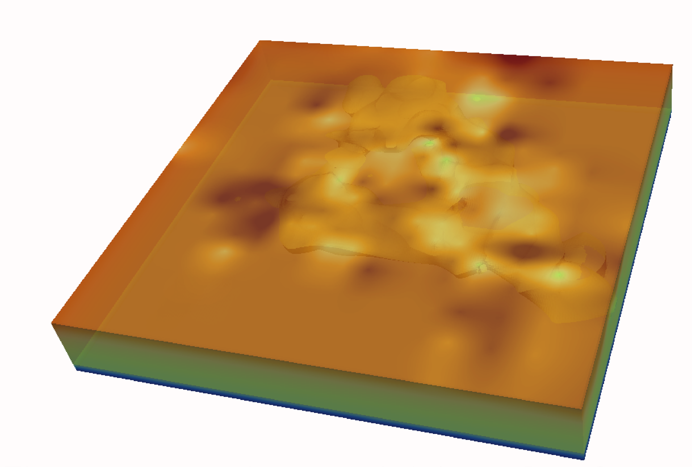
We built up a high-resolution three-dimensional flat model ~20 km thick spanning a surface of about 13500 km^2 in the Central Italy.

Surface topography having 500m spatial resolution has been incorporated within the model.

The rheological properties of the domain were deduced from a vp/vs travel time tomographic model.

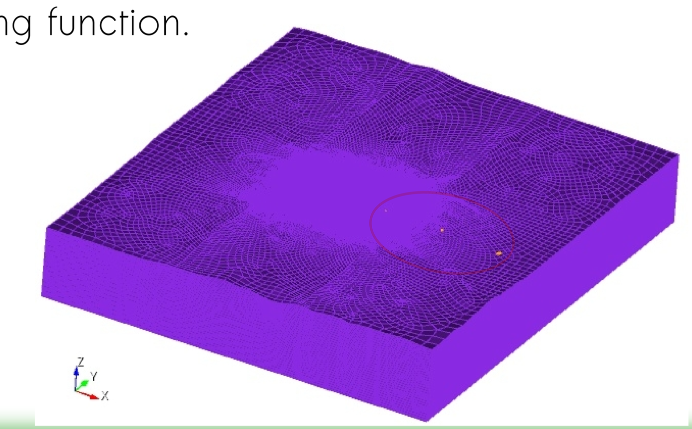


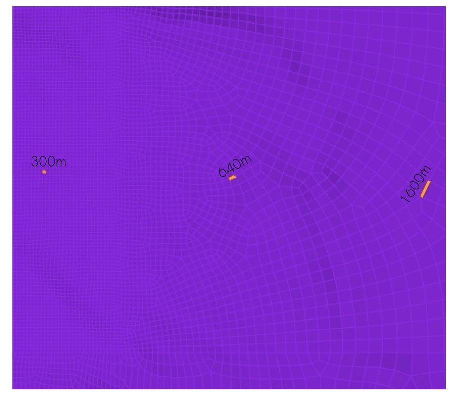
The domain was discretized using 20-nodes brick elements. The generated unstructured mesh contains 1461474 elements, resulting in 5933380 nodes. The element horizontal size is biased from 300m to 2-3km using the paving meshing algorithm in combination with an appropriate adaptive sizing function.



The tomographic model from De Gori et al (2010).

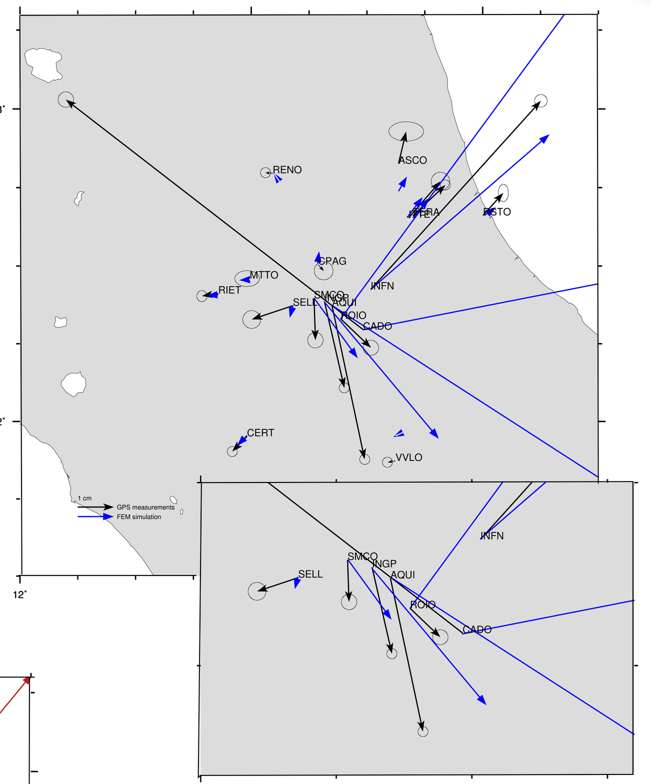
De Gori et al, submitted

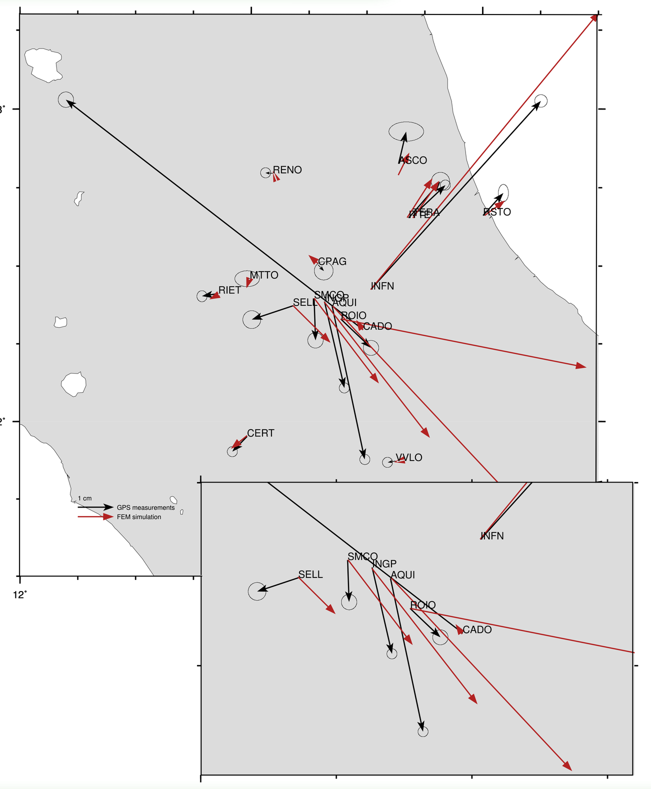


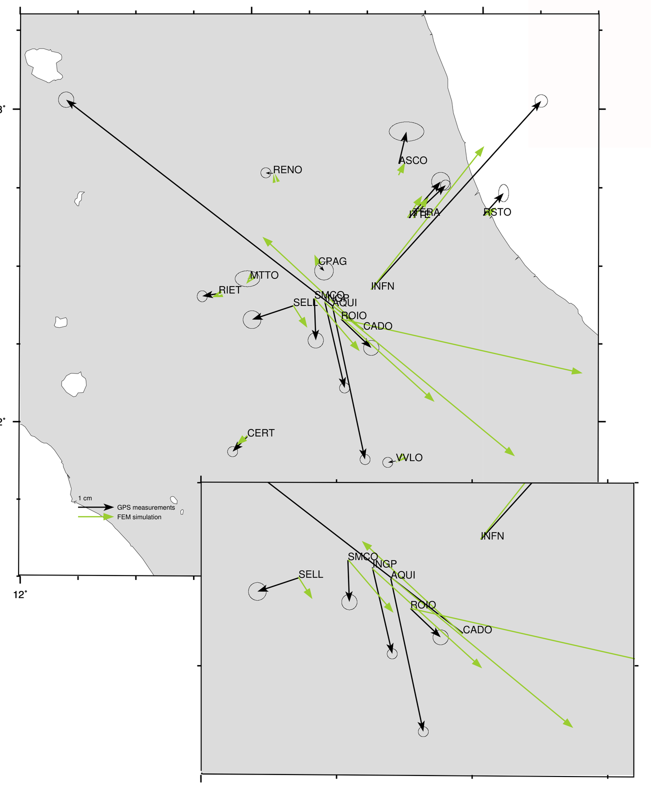


A detail of the mesh biasing

RESULTS







The calculated coseismic displacement field is compared with GPS measurements from Anzidei et al. 2009.

3D plots of the horizontal and vertical deformation field obtained with source 3 (Atzori et al. 2009).